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CONTEMPORARY SCHOLARSHIP

Immersive Synthetic Memories

Transforming AI Generated 2D Memories into Virtual Environments

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ABSTRACT

The DDS Synthetic Memories project has developed techniques using Gen-AI technologies to recreate past visual experiences that may have faded, changed, or been forgotten. The Immersive Synthetic Memories project extends these efforts to immerse subjects in virtual recreations of their memories. The installation invites participants into an intimate setting to recall memories instantly rendered with generative AI and spatialized for VR headsets. The project is a collaboration with Barcelona-based Domestic Data Streamers (DDS), the University of Southern California's Mobile & Environmental Media Lab, and Scott Fisher's course Spatial Imaging for XR. This paper explores the artistic and technical processes, the AI pipeline converting 2D visuals into 3D 180° immersive spaces, development challenges, and potential applications in mental health and memory studies.

Synthetic Memories is a research initiative that preserves personal memories at risk of being lost and explores the role of AI technology in memory preservation and the building of individual and collective identities. It recreates past visual personal memories that have been erased or have never been documented by converting spoken and written descriptions into images using artificial intelligence.

A Synthetic Memory is a digitally reconstructed visual representation of a personal memory created with generative artificial intelligence (GEN-AI) tools. Unlike our natural memories, which are created and stored in the human brain, Synthetic Memories are produced by algorithms. The process involves people sharing detailed descriptions of their experiences. These descriptions are then used to create AI-generated images and short videos, capturing the essence of the memories shared.

Synthetic Memories is an inherently interdisciplinary initiative, integrating fields such as cognitive psychology, digital humanities, AI, arts, culture, and design. It combines technological innovation with a deep understanding of human memory and identity.

It has been implemented in museums, schools, community and cultural centers, hospitals, care homes, and public spaces around the globe to help individuals and communities engage in meaningful dialogue about the past, unlocking the potential to enrich both the present and the future.

Synthetic Memories is an initiative started by Domestic Data Streamers, a collective from Barcelona who have been focusing on exploring new data languages and their social implications since 2013; a team of 30 people from a broad spectrum of fields, from design, engineering, journalism, and architecture to art history and psychology.

THE PROCESS OF RECREATING A 2D MEMORY

Generating a Synthetic Memory begins with a one-on-one interview, where the individual is asked to describe the specific memory they want to visualize. Based on their descriptions, the interviewer guides the individual in the selection of one memory that can be transformed into a tangible image (Fig. 1). The prompter then generates a series of images to represent that memory. These images are shown to the interviewee and adjusted based on their feedback until one fully aligns with their recollection. Once the participant recognizes an image as a meaningful representation, it is given to the individual (virtually and on paper) and saved in the Synthetic Memories Archive. A one-hour structured conversation explores the participant's most vivid memories, focusing on experiences with precise visual details. The interviewer asks questions to uncover personal narratives, cultural elements, and specific temporal-spatial contexts. In our

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Fig. 1. Interview setup showing interviewer, interviewee, and prompter during the memory collection process. (© Domestic Data Streamers)

implementation, users are able to navigate with six degrees of freedom, moving through the reconstructed memory spaces in VR to explore different perspectives and spatial depths.

The collected descriptions are translated into structured prompts for generative AI models (DALL·E2, ImageFX, or Stable Diffusion). Each prompt generates multiple image variations for participant review. Participants evaluate generated images in real time, providing feedback on accuracy and suggesting modifications to textures, composition, and context. This iterative process continues until images align with recollections (Fig. 2), typically producing 2–3 final memories per session. Finalized memories are digitally archived and provided to participants. Optional collective implementations include curated exhibitions, installations, or documentaries for broader sociocultural analysis.

PROJECT TRAJECTORY

Initial research began in 2022 at Domestic Data Streamers headquarters, testing memory reconstruction methodology

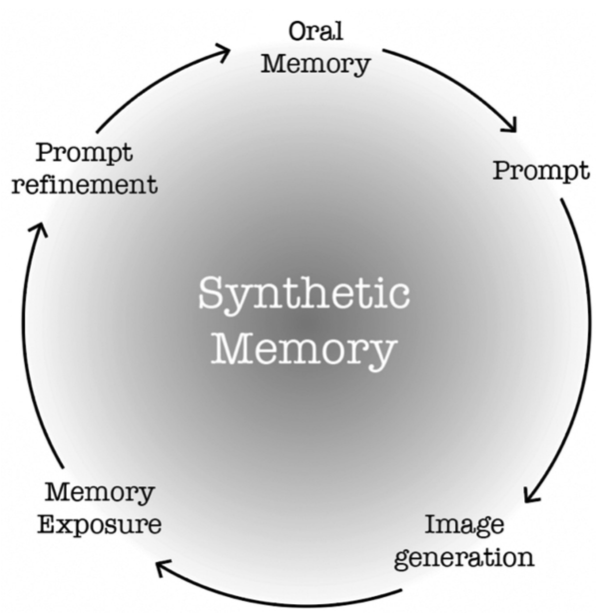

Fig. 2. Iterative memory workflow: oral recollections are refined into AI-generated visuals through cycles of prompt, exposure, and feedback. (© Domestic Data Streamers)

using early generative AI platforms. The pilot established baseline protocols through controlled testing with elderly family members. A subsequent study at a Barcelona nursing home involved 35 elderly residents, exploring reminiscence therapy applications and methodology adaptations for varying cognitive conditions.

In 2023, collaboration with São Paulo's Casa do Povo cultural center tested the methodology with Bolivian and Korean diaspora communities, focusing on migration memories. The project included interviews, AI-generated visualizations, and a community exhibition. The Citizens' Office of Synthetic Memories launched in 2024 at Barcelona's Design Hub Museum, providing the first public memory reconstruction service. Operating in a 400-square-meter space, a research team conducted systematic sessions over three months, establishing both digital and physical Synthetic Memories archives.

Exploring 3D Memory Reconstruction and VR Experiences

Since this research initiative's first explorations, all the Synthetic Memories have been reconstructed in 2D AI-generated images, animated images (GIFs), or AI-generated videos. The current research aims to explore the expansion of Synthetic Memories into immersive environments through a collaborative study by Domestic Data Streamers and USC's Mobile & Environmental Media Lab. Initial findings from this experimental phase demonstrate the feasibility of translating participant 2D memories into navigable 3D spaces while maintaining emotional fidelity. This technological advancement enables spatial exploration of reconstructed memories, marking a significant methodological evolution in memory visualization techniques. The project aims to explore how generative tools combined with immersive media can reconstruct memory visually and spatially. This approach also draws on broader art historical frameworks that treat memory as a mediated process that changes over time, as discussed in González's work on contemporary art and remembrance [1]. By positioning memory within evolving technological and artistic structures, the project extends the argument that art doesn't just represent memory but also plays a part in reshaping it through form, medium, and audience interaction.

We developed two distinct pipelines to create these immersive memories: the 180° pipeline and the Gaussian splatting pipeline, each offering unique approaches to rendering AI-generated visuals into immersive environments. In the 180° immersive environments, users inhabit a fixed point of view with head tracking that is not fully navigable. The Gaussian splatting version has six degrees of freedom (6DoF), which gives users full freedom of moving and rotating in the virtual environment.

Collaboration between DDS and USC

Early in 2023, USC School of Cinematic Arts professor Scott Fisher connected with DDS to propose the development of a VR portion of the Synthetic Memories project. To expand the project's scope and provide practical learning opportunities, Fisher integrated the initiative into a Media Arts Research

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Fig. 3. From left to right: AI-generated image created in MidJourney (2024); fisheye-converted image prepared in Photoshop (2024). (© Domestic Data Streamers)

Lab course, Spatial Imaging for XR. This course engaged students in creating immersive prototypes, using generative AI tools to transform memory descriptions into VR-compatible visual scenarios. The collaboration not only advanced the project but also allowed students to gain hands-on experience in immersive media and AI development.

Pipeline 1: Designing for 3D 180° Visualizations

The project underwent rigorous testing of multiple pipelines and AI tools to ensure maximum control over the visual outputs, essential for the installation's real-time creation of memories. Early in the process, we explored various generative AI platforms, including Runway Gen-2 and Luma AI, to assess their capabilities in translating textual memory descriptions into visually coherent outputs.

Starting with generative AI tools like Runway Gen-2 and Luma AI, initial visuals were created and tested for their ability to capture the emotional essence of participant narratives. Students conducted experiments by visualizing their own memories, using them as case studies to refine the process. In each class, their work was reviewed collectively to discuss what was effective and identify areas for improvement. Initial experiments were focused on creating still 2D images following the pipeline DDS provided and then adding an immersive element, whether it was making them 3Dor converting to 180° or 360° environments. These visuals were then converted into 180° fisheye environments using Photoshop's generative expand tool and Midjourney, optimizing for compatibility with VR headsets like the Meta Quest and Apple Vision Pro (Fig. 3).

The tools we use are all publicly available, and similar technical workflows do exist online. However, our contribution lies in developing a cohesive and emotionally responsive workflow as part of a participatory art installation. Every stage of the process involves aesthetic decisions, emotional connections, and technical prowess to create an integrated artistic process for reimagining memories. We are aiming to reframe AI as a medium for memory-driven storytelling.

The decision to use 180° rather than 360° was based on both technical and experiential considerations: 180° allowed for faster rendering and real-time adaptability during installations while providing an intimate and focused viewing experience for participants. The 360° format was found to be too buggy and visually overwhelming, making it difficult to maintain a comfortable and cohesive experience for the viewer. Motion was also incorporated into the visuals using Runway Gen-2 in response to DDS's recommendation to include subtle movement to enhance immersion. This slight motion enhanced depth and realism, making the memory reconstructions more engaging and lifelike for participants. To further elevate the 180° experience, Immersity was utilized to incorporate 3D stereoscopic imagery, enriching the spatial depth and creating a more immersive and realistic experience when viewed in VR headsets (Fig. 4).

Sound was generated using MyEdit and ElevenLabs to craft an atmospheric experience, highlighting the critical role of audio in enhancing VR projects. The integration of spatial and ambient audio provided an additional layer of immersion, helping participants feel more connected to the memory reconstructions.

Pipeline 1: Technical Challenges

Translating 2D AI-generated images into immersive VR environments posed significant challenges, particularly in preserving the emotional resonance of the original memory. This process required extensive experimentation with AI tools to transform flat, static visuals into dynamic 3D 180° spaces while maintaining their emotional impact (Fig. 5). Months of refinement ensured the pipeline balanced technical precision with artistic intent, using depth mapping, lighting, textures, and sound design to evoke a sense of presence and connection. We achieved this balance through critique sessions during class time, having students test pipelines on their own memories, and constant communication and feedback from DDS on iterations of the workflows.

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Fig. 4. Stereoscopic 180° image formatted in Immersity for VR headset display (2024). (© Domestic Data Streamers)

One major hurdle was maintaining a sense of abstraction in the VR environment. Blurred faces and vague textures, effective in 2D, often appeared unsettling or disorienting in VR. This required rethinking visual techniques to balance clarity and abstraction, ensuring users could connect personally with reconstructed memories without feeling discomfort. Blurring and softening the visuals were key methods to prioritize the feeling of the memory rather than its literal appearance, allowing emotional impact to lead the way.

Sound design introduced further complexities, especially when incorporating AI-generated voices. Users often expected perfect replication of individuals' voices, and discrepancies between expectations and results sometimes led to disappointment. Despite emphasis that the project is an experimental visualization, managing user expectations remained a challenge.

These difficulties highlighted the intricacies of using immersive media for emotional storytelling. Successfully creating evocative memory reconstructions required technical expertise, nuanced understanding of human perception, and careful curation of visual and auditory elements. This curation involved designing soundscapes that layered ambient and diegetic sounds to reflect the participants' memory environment. For example, we combined house noises—like a refrigerator hum, clock ticking, or creaking floorboards—with specific music or AI-generated voices, albeit intentionally abstracted to avoid uncanny associations. The project underscored the need for a delicate balance between abstraction and realism. Avoiding things like sharp facial features, photorealistic textures and distinct human voices was key in avoiding an uncanny feeling in VR.

Pipeline 2: Navigable 3D Memory Spaces with Gaussian Splatting

Navigation in immersive spaces plays a transformative role in enhancing cognitive engagement and fostering deeper interactions with virtual environments by enabling six degrees of freedom, allowing users to achieve greater immersion [2]. Users are able to move through the virtual experience in any direction and rotate along three axes, providing full spatial access and perception to the memory. In memory reconstruction, navigable environments stimulate memory by engaging users in synthetic memories with stronger emotional and cognitive responses. However, creating navigable spaces, particularly through AI generation, faces challenges such as limited cohesive 3D space generation and dataset diversity, with no stable models for generating spatially consistent environments from abstract inputs [3–5]. Photogrammetry algorithms, which offer accurate spatial representation, on the other hand, present a more viable approach for creating navigable spaces in this context.

In our methodology for reconstructing navigable memory spaces from AI-generated representations, we utilize 3D Gaussian splatting to convert a single AI-generated image, derived from interview responses, into an immersive environment as shown in Fig. 6. Using the Marigold model, we estimate a depth map from the input image to transition from 2D to 3D space [6].

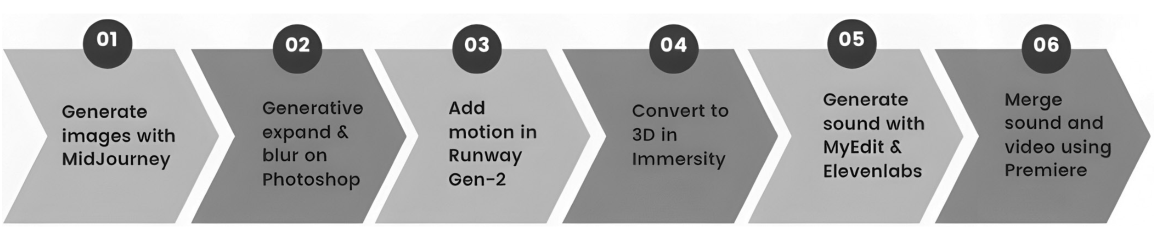

Fig. 5. Six-step workflow for creating 3D 180° immersive memory scenes using generative AI tools. (© Domestic Data Streamers)

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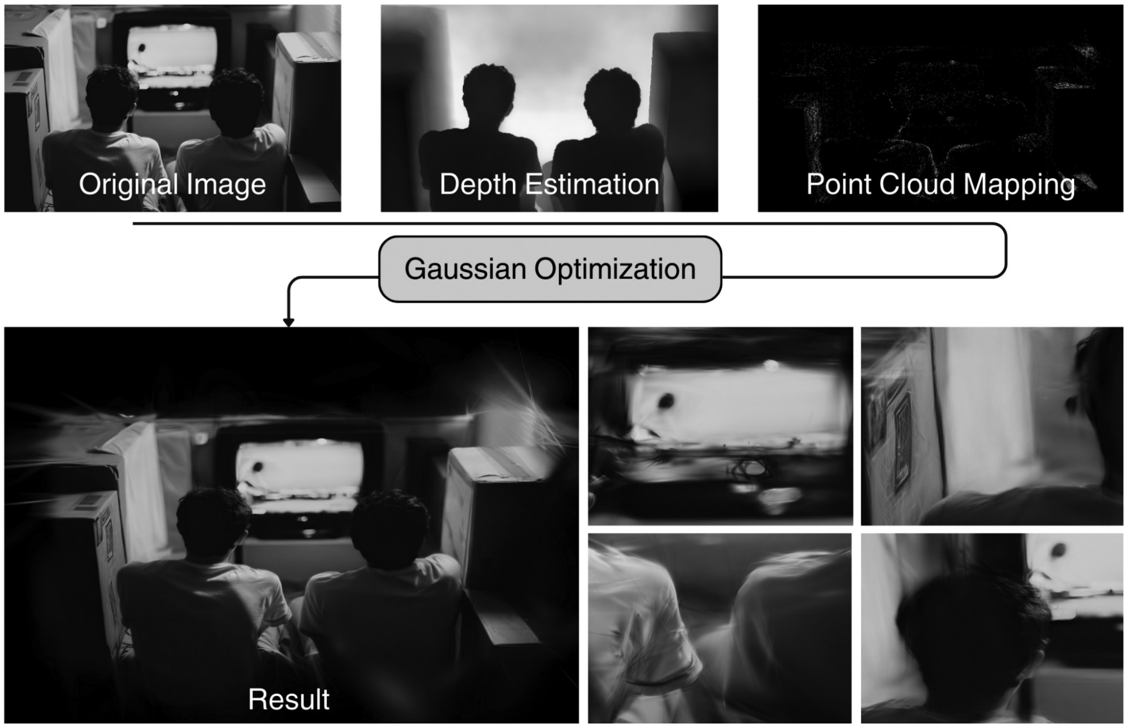

Fig. 6. Workflow for converting AI-generated images into immersive 3D environments using Gaussian splatting. The process begins with depth estimation and point cloud mapping, followed by Gaussian optimization to create a spatially explorable memory. (© Domestic Data Streamers)

The image is then decomposed into 3D Gaussian ellipsoids, each defined by parameters such as position, size, color, and orientation. These Gaussians, paired with spherical harmonics to capture color variations from different viewing angles, replace traditional polygonal meshes. Through an efficient iterative optimization process, the overlapping Gaussians are blended seamlessly to recreate the original image's appearance, with the pipeline completing training in approximately one minute per image with an RTX3090.

Pipeline 2: Abstracting Memory with Gaussian Splatting

Gaussian splatting offers a unique capacity for abstraction, differing from traditional photogrammetry or NeRF by prioritizing artistic interpretation over photorealism, aligning more closely with subjective experiences of memory. We intentionally reduce the number of Gaussians assigned to each image, achieving less photorealistic representations. The transparency and elliptical shape of Gaussians ensure spatial inaccuracies appear as soft, blended forms rather than sharp artifacts. As shown in Fig. 6, input image borders blend with the surrounding space, reducing the unnaturalness of a 2D object in 3D. Missing details resemble stains and grains of aged photographs, evoking nostalgia. When navigating closer, users encounter elliptical Gaussians varying in size, shape, and orientation, blending colors into immersive shades. By capturing essence over exactness, this method mirrors human memory perception, amplifying emotional connections in therapeutic and artistic contexts.

Pipeline 2: Technical Challenges in 180° Immersive Environments

Shifting from photorealism to abstraction introduces challenges in managing depth and Gaussian density. Excessive depth creates unnatural gaps, while shallow depth flattens scenes. Depth balancing requires adjustments like interpolating gaps and resizing Gaussians. Gaussian density also affects resolution. Lower density evokes dream-like qualities but risks blurriness, while overly dense Gaussians create static, photo-like effects. Achieving the ideal density demands iterative testing based on image detail and VR experience.

COMPARING PIPELINES

While both pipelines reconstruct memories in immersive media, they offer varying degrees of capability. The first pipeline is essentially a continuation of the original 2D image generation process by DDS. While this lacks interactivity and is limited in navigability, the familiarity of still moments coming to life creates a sense of nostalgia or melancholy and thus a distinct sense of connection to the memory visualization. The tension between the photoreal clarity and the blurred distortion evokes the unstable nature of memory itself. The second pipeline builds on the output of the first by transforming the final imagery into a fully navigable space via Gaussian splatting. While there is a trade-off with visual consistency, the 6 degrees of freedom of Pipeline 2 immerses users in a deeper way and gives them more agency in exploration as opposed to a passive re-experience of memories.

Together, these pipelines demonstrate an evolving process of experimentation across visual mediums to explore how generative AI can mediate personal memory. Our past is constantly reimagined through emerging media as new tools and methods of interaction continuously reshape how we visualize memory. The project aims to artistically explore how cinematic immersion or spatial navigation can engage with the fluid nature of recall.

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KEY OUTCOMES

The Immersive Synthetic Memories project premiered at the inaugural Flux Festival (20–23 November 2024) in Los Angeles, showcasing its immersive installation. Presented in collaboration with AI for Media & Storytelling (AIMS) a collaborative initiative of USC's School of Cinematic Arts and the Annenberg School for Communication and Journalism, the project invited audiences to experience real-time memory reconstruction, aligning with Flux's mission to highlight cutting-edge creative experiments with emerging platforms and technologies.

The project elicited positive emotional responses from participants, many of whom described the experience as deeply personal. Among the most striking testimonials was that of a New Orleans Hurricane Katrina survivor, who described the VR memory reconstruction as a "transcendent and healing experience." This participant emphasized the importance of the project as an "opportunity for both closure and renewal" and the critical role that such a use of technology could play in addressing personal and collective trauma. He spoke of how the innovative application of this research offered a means of preserving and engaging with memories otherwise lost to time or distorted by emotional pain that victims of tragedies like himself and his family could use and in his words "need."

Through iterative testing, we established a reproducible pipeline for converting 2D AI-generated images into 180° VR environments. The implementation demonstrated that Gaussian Splatting, when optimized for memory reconstruction, achieved rendering times of approximately one minute per input image while maintaining spatial coherence. This represents a significant improvement over traditional NeRF approaches, which typically require lengthy training periods.

The research also identified optimal parameters for depth mapping and Gaussian density in memory visualization. Analysis showed that excessive depth scaling led to spatial distortions, while insufficient depth resulted in decreased immersion. The findings indicated that maintaining Gaussian density within a specific range was crucial for achieving both recognizable objects and the desired level of abstraction in the VR environment.

The study also established a systematic methodology for translating oral memory descriptions into immersive experiences through a documented three-stage process: initial 2D generation, depth estimation using the Marigold model, and optimization through Gaussian splatting. This framework provides a replicable approach for future research in memory visualization.

In the course of this work, one central observation emerged: The immersive reconstruction of memories in a virtual reality context appeared to induce heightened emotional engagement. Participants reported a stronger sense of presence and affective resonance when the memories, originally generated as static images, were transformed into spatially coherent environments. This finding is consistent with studies suggesting that spatial awareness and environmental cues play a significant role in human recall processes. Moreover, this work is part of the growing field of AI-based memory reconstruction in contemporary art, such as ReCollection [7], which similarly generates memories of participants into AI visuals. Both projects explore the fragility of memories and how AI can fill the gaps by pushing the boundary between memory and imagination. What's important to highlight is that the core of these types of art projects is experiential, not theoretical. Furthering this experiential focus, Immersive Synthetic Memories also examines the power of sound in reconstructing memories.

Although the project's sound design, aided by MyEdit and ElevenLabs tools, enriched the immersive ambience, it also highlighted limitations in replicating personal voices with precision. Some participants arrived with the assumption that the voices they heard would precisely match those in their memories, and deviations from those expectations occasionally brought about disappointment. Nonetheless, the integration of auditory components continued to be a powerful enhancer of emotional realism, as it offered an additional sensory anchor that supported the overall narrative experience.

Taken together, these developments underscore the potential of immersive media for advanced memory preservation and emotional engagement. The capacity of users to step into a constructed scene and explore the environment from various angles introduced a degree of authenticity not observable in static visual outputs. However, it also became apparent that immersive platforms such as VR demand meticulous calibration of visual, auditory, and interactive elements to avoid undermining the intended emotional effect.

CONCLUSION AND FUTURE DIRECTIONS

The Synthetic Memories project highlights the potential of blending generative AI, immersive media, and interdisciplinary collaboration. Future iterations will refine the pipeline for greater adaptability and explore more dynamic, interactive elements to engage diverse narratives. Moving forward, we aim to focus the project on supporting individuals who experience memory loss and cultural loss, offering a tool to rekindle personal and collective histories. We encourage artists and technologists to collaborate in advancing immersive storytelling, pushing creative boundaries, and reimagining how art and technology shape memory and identity.

The evidence gathered through this research demonstrates both the technical feasibility and the methodological challenges of translating personal memories into navigable VR environments. The study's primary contribution lies in establishing a quantifiable approach to memory visualization using current AI and VR technologies, with specific attention to the technical parameters that influence spatial representation and perceptual accuracy.

Future research directions emerge directly from our findings, particularly in the development of standardized metrics for evaluating the fidelity of memory reconstructions in VR. This includes the need for quantitative measures of spatial accuracy and perceptual consistency, which would enable better comparison between different visualization techniques.

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Technical optimization studies should focus on establishing precise relationships between Gaussian density and spatial coherence while quantifying the correlation between depth mapping accuracy and perceived immersion.

Systematic comparative analysis between different 3D reconstruction methods, including NeRF, traditional photogrammetry, and Gaussian splatting will be essential for establishing quantitative benchmarks in memory visualization applications. Such studies should employ controlled testing environments to measure rendering efficiency, spatial accuracy, and perceptual quality across these different approaches.

Additionally, methodological refinement is needed in several key areas, including the standardization of memory collection protocols and the development of verification methods for spatial accuracy. Future work should focus on creating reproducible procedures for translating narrative descriptions into visual parameters, with particular attention to maintaining consistency across different implementations.

These research directions emphasize the need for continued investigation into both the technical and methodological aspects of immersive memory reconstruction. The current findings provide a foundation for deeper investigation into the intersection of memory visualization and immersive technologies, while acknowledging the need for more extensive validation of the observed phenomena.

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